World Journal of Applied Chemistry
2017; 2(4): 129-133
http://www.sciencepublishinggroup.com/j/wjac
doi: 10.11648/j.wjac.20170204.12

Chemical Analysis of the Iron, Sodium, Potassium, Titanium and Aluminum Content of Kaolin Sample from Kankara, Kastina Nigeria

Zerendu Christian[1, *], Okorn George[1], Raji Saheed Akinleye[2], Ibraheem Wasiu Aderemi[1]

[1]Department of Chemistry, Faculty of Physical Sciences, Ahmadu Bello University Zaria, Zaria, Nigeria

[2]Chemical Engineering Department, Faculty of Engineering, Ladoke Akintola University of Technology, Ogbomosho, Nigeria

Email address:

fellow4real55@gmail.com (Z. Christian)

[*]Corresponding author

To cite this article:

Zerendu Christian, Okorn George, Raji Saheed Akinleye, Ibraheem Wasiu Aderemi. Chemical Analysis of the Iron, Sodium, Potassium, Titanium and Aluminum Content of Kaolin Sample from Kankara, Kastina Nigeria. *World Journal of Applied Chemistry.* Vol. 2, No. 4, 2017, pp. 129-133. doi: 10.11648/j.wjac.20170204.12

Received: August 14, 2017; **Accepted**: August 30, 2017; **Published**: September 30, 2017

Abstract: A total of 100 Clay samples was collected from Kankara Mengwa and Kankara Babangida and were analyzed for their Na, K, Fe, Al and Ti content using Instrumental Neutron Activation Analysis with Near Infra-Red analytical techniques. The result of the analysis hinted that the Kankara Mengwa kaolin is more qualitative than Kankara Babangida because of its low iron content, high aluminum content, low alkaline metal (Na and K) and low Ti content. It is envisaged that the findings of this research would provide substantial information that will trigger large scale industrial use of this clay.

Keywords: Kaolin, Kankara, Neutron Activation, Near Infrared, Clay

1. Introduction

Clays are aluminosilicate minerals [1] which have many industrial applications [2]. Kaolin is represented chemically as $Al_2O_3SiO_2.H_2O$. The theoretical oxide ratio corresponding to the kaolinite formula is; Alumina, Al_2O_3 (42.46%), Silica, SiO_2 (50.04%) and water, H_2O (7.59%) [3].

Kaolin has a wide range of industrial applications outside the ceramic industries and they include Paint industries where it is used as extender in calcined form owing to its good suspension properties, permitting high pigment loading and imparting a desirable and easily controllable surface properties on paints [3,4]. Because of its smoothness, inertness and stability over a range of P^H, it is used in pharmaceutical industries as intestinal adsorbent to combat intestinal irritation. In paper industries, it is used as filter or coating agent because of its low abrasiveness, whiteness, low residence of non-plastic constituents and lower viscosity at high solid content [5].

The analysis of the Iron, Sodium, Potassium, Titanium and Aluminum content of clay will help ascertain its suitability for use in ceramics and other industrial applications. Among the most recent research work on Kankara clay to the best of our knowledge are reviewed below;

Ajayi and Adefila [6] in 2012 carried out a Comparative Study of Chemical and Biological Methods of Beneficiation of Kankara Kaolin. In their work, chemical and biological leaching of iron rich kaolin sample was carried out using sulphuric acid, oxalic acid, cultured and un-cultured Aspergillus niger (A. niger). The kinetics of leaching determined from XRF analysis was observed to be higher for acid compared to biological method and at shorter contact time. The conversion of alumina for oxalic, sulphuric, un-cultured and cultured A. niger were determined to be 77.81, 87.73, 26.38 and 28.37, respectively; while that of iron were 66.07, 98.32, 25.71 and 28.51. The kaolin leached with un-cultured A. niger was observed to digest both alumina and iron at an enhanced rate in the first 6 days, while the cultured remained inactive due to adaptation, for the same number of days. The cultured A. niger was later observed to leach more than the un-cultured one despite the adaptation period, it went through.

Lori *et al*., [7] in 2007 also carried out characterisation and optimisation of deferration of Kankara clay. The mineralogy of the clay deposit was studied by x-ray diffraction (XRD). Iron impurities (FeOOH), alumina (Al_2O_3) and silica (SiO_2)

contents of untreated and beneficiated clays were monitored by Energy Dispersive X-ray Fluorescence (EDXRF). It was found that the optimum conditions for about 99% deferration were temperature of 75°C, oxalic acid concentration of 1.8mol/dm3 and shearing time of 7hrs. The use of magnetic separator, showed no improvement on iron removal from the clay.

Aderiye [8] in 2014 in his work entitled; Characterisation of the Nigerian Kankara Kaolinite clay particulates for automobile friction lining material development hinted that Kankara clay could be technically employed as friction linning material for very high thermal characteristics properties; medical reasons; environmental friendliness and economic considerations in automobile disc brake pad production.

Source, Chemistry and Physical Properties

Kaolin is a weathering product of silicate rock naturally occurring hydrated aluminium silicate which is white, yellowish-white, earthy, nonporous and odourless to dull material having a plastic touch and slightly oily feel [9]. It is also almost tasteless and practically insoluble in water [10-11]. It has the median particle size range of commercial products varying between 0.1-10microns [9]. The hydrophilic surface of kaolin allows it to be easily dispersed in water at neutral pH of 6-8. The other common physical properties of kaolin are; platy shape, high brightness (80-95). specific gravity (2.58-2.63), refractive index (1.56-1.62) and mohs hardness of 2-3 [12]

2. Methodology

A total of 100 Clay samples was collected from two sites; 40 from Kankara Mengwa (KM) at a depth of 4m and 60 samples from Kankara Babangida (KB) at depth of 12.8m as indicated in the enclosed map of Kankara as shown in Figure 1. The area lies at Latitude 11^0 55 and Longitude 7^0 25 North-west. The vegetation in the selected sites was cleared with a machete and the top soil which normally contained a lot of organic matter removed. Equipment and machines for drilling and mining had not been installed in any of the sites, therefore the Kaolins were dug out manually with holes, diggers and shovels from well-like boreholes, sometimes diverting into underground tunnels. Samples were collected manually into polyethylene bags at the sites. The samples were oven-dried at a temperature of about 103°C and homogenized by grinding using wooden mortar and pestle to powdery form. They were stored in plastic polyethylene bags.

Figure 1. Location map of Kankara Kaolin Deposit [13].

Metal Determination

Two analytical procedures of Instrumental Neutron Activation Analysis (INAA) with Near Infra-Red (NIRR-1) were used. Standard certified reference material of the Chinese geo-chemical rock standard GSD-11 and GSR-5 were used as standard for analytical quality control to validate the procedure of elements of interest in the samples [14]. The first technique involved a short irradiation regime, followed by gamma-ray measurements after appropriate decay periods and suitable for Al, K, Ti and Na. Fe was identified and quantified using the second procedure which involves a long irradiation regime of 6-7hrs.

3. Results and Discussion

Table 1. *Elemental composition of Kaolin samples from KB and KM sites.*

Element	KB	KM
Al (%)	15.87	18.68
Alumina content	30	35.3
Fe (%)	0.22	0.000024
Ti (ppm)	1733.5	BDL
K (%)	3.32	0.5
Na (%)	0.14	0.045

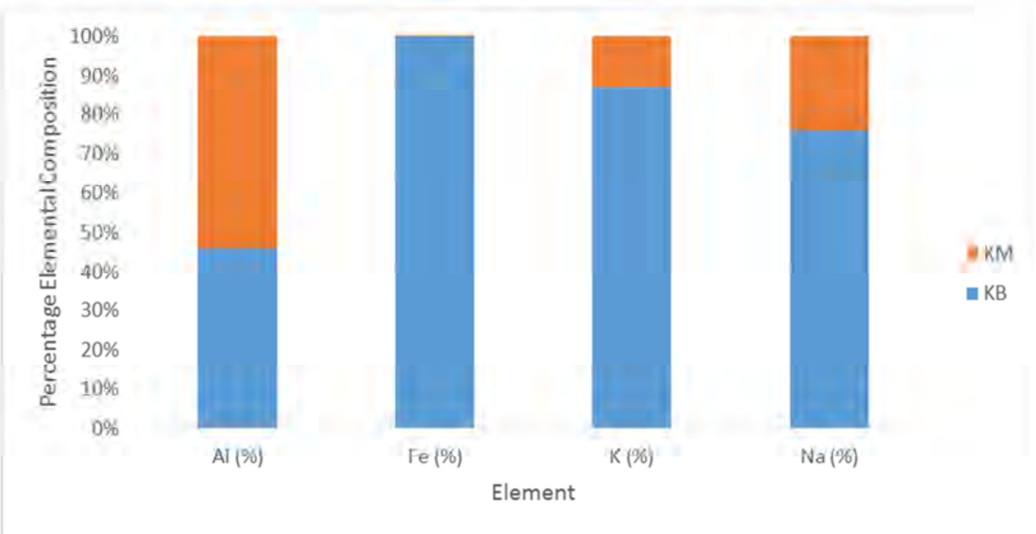

Figure 2. *Percentage Elemental Composition of KB and KM Kaolin.*

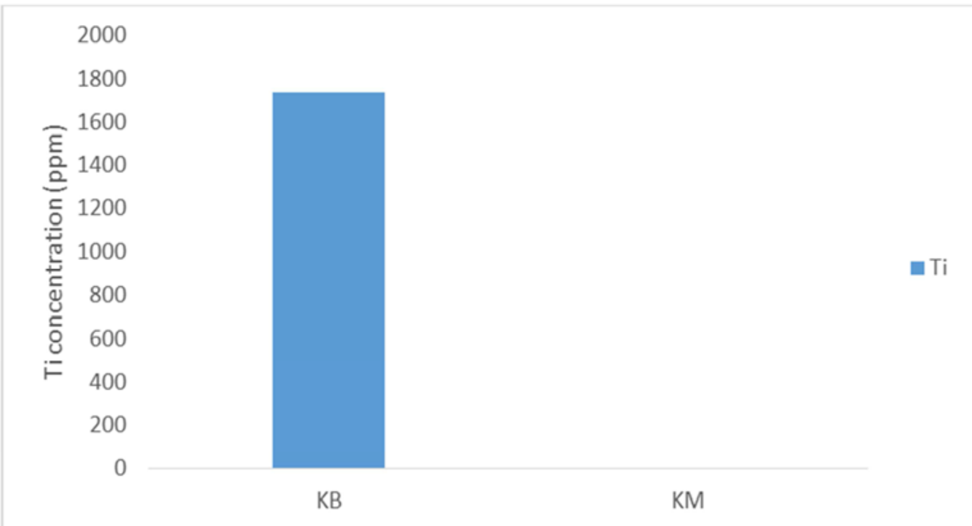

Figure 3. *Concentration in ppm of Ti content of KB and KM kaolin.*

The percentage composition of Al in the kaolin samples ranges between 18.68% (for KM) and 15.87 (for KB). Thus, it can be inferred that Kaolin sample from KB site recorded the highest Al content as depicted in Table 1 and Figure 2. Their Aluminum content determines their corresponding alumina content which also determine their purity and quality [15]. Based on the Al content, the purity and quality of the kaolin from the two sites is in the order: KM > KB as indicated in Figure 2. The alumina, Al_2O_3 content (35.3%) for the KM sites corresponds with the values reported in literature. Robinson [16] reported 34.49%, Aderibigbe and Chukwunogo [17] recorded 38.64% for Kankara kaolin.

The KB kaolin recorded the highest Fe content of 0.22% and the KM kaolin with Fe content of 0.000024% recorded the least as shown in Table 1 and Figure 2. Aderibigbe and Chukwunogo [17] result is in agreement with that of KM, only that it recorded it as nil. Robinson [16] reported 1.17% Fe_2O_3 for Kankara. The variation of Fe and Al_2O_3 contents with time suggest that the quality and purity changes with time. Therefore the quality of the kaolin samples cannot be assumed constant all the time. Hence, the constituents of the kaolin clay should be constantly ascertained so as to know the quality, usefulness and chemical treatment on them for effective and economical use. The KB kaolin with high Fe content is lower in purity and quality than KM sample for use in paper, ceramics, porcelain, alumina and plastic industries where the presence of Fe is detested. However, the Fe content of KB kaolin could enhance its usefulness for alum production, since Fe is used as a coagulant [17] and in classical coagulation [18]. Its quality and purity could be improved for other uses by beneficiation of the iron [19].

KB kaolin has the highest K mean content of 3.32% and KM kaolin the least with 0.5% K content as shown in Table 1 and Figure 2. The finding of Robinson [16] for Kankara was given as 0.27%. This value from Robinson is twelve times less than that of KB kaolin and twice less than that of KM kaolin. This suggests that the content of the alien constituent of the kaolins changes with time and site of collection.

Johnston and Johnstone [20] stated that pure kaolins should have negligible content of alkaline earths and good quality kaolins contains less alkali metal [21]. These statements suggest that the lesser the alkali metal, the more the purity and the better their quality.

The sodium contents of the analyzed kaolins ranged from the highest 0.14% for KB and the least 0.045% for KM. The finding of Robinson [16] for Na in Kankara correspond to 0.14%. Unlike the K content, Robinson [16] Na value is less than that of KB but almost twice that of KM. This furthers show that the Na concentration has changed with time. The Na content from the report of Robinson [16] is less than that of KM. The Na content of the analyzed samples could enhance their uses for making drugs for diarrhea treatment since it helps in the replacement of lost electrolytes [22].

KB has the highest Ti content of 1733.5ppm while the content for KM was below detection limit as illustrated in Table 1 and Figure 3. Porcelain materials require clay materials with minimal Ti content to enhance translucency [3]. This implies that the undetectable Ti content of KM may enhance their use for porcelain products.

4. Conclusion

Comparatively, KM kaolin is more qualitative than KB kaolin because of its low iron content, high aluminum content, low alkaline metal (Na and K) and low Ti content. The Robinson report of 1979 on Kankara kaolin of Kastina corresponds favorably to KM kaolin, which is more qualitative than the KB kaolin. In view of the high quality of KM kaolin as pointed out by this research finding, it may be recommended as a good source of Kaolin clay for clay based industries.

References

[1] Grimshaw RW (1971). The Chemistry and Physics of Clays and Allied Ceramic Materials. Ernest Benn Ltd, 4th Ed 1971. 1:29.

[2] Murray HD (2002). Industrial Clays: Case Study. International Institute for Environment and Development (IIED). England. pp. 1-4.

[3] Hansen, T. (2003). Titanium oxide, Titania. Ceramic materials Data Base. Retrieved 10 August, 2017 from http://ceramicmaterials.com/com/cermat/html

[4] Muriithi, N. T., Karoki K. B., Gachanja A. N. (2012). Chemical and mineral analyses of Mwea clays. International Journal of Physical Sciences, 7(44), 5865-5869.

[5] Judy, M. (2000). White Washing Agriculture. Retrieved 11 August, 2017 from http://www.encyclopedia.com/doc

[6] Ajayi, O. A., Adefila, S. S. (2012). Comparative Study of Chemical and Biological Methods of Beneficiation of Kankara Kaolin, International journal of scientific & technology research, 1 (8):13-18.

[7] Lori J. A., Lawal A. O., Ekanem E. J. (2007). Characterisation and optimisation of deferration of Kankara clay, Journal of Engineering and Applied Sciences, 2(5): 60-74.

[8] Aderiye Jide (2014). Characterisation of the Nigerian Kankara Kaolinite Clay Particulates for Automobile Friction Lining Material Development. *Chemical and Process Engineering Research*, 29: 24-34.

[9] Gushit, J. S., Olotu, P. N., Maikudi, S., Gyang, J. D. (2010). Overview of the availability and utilization of Kaolin as a potential raw material in chemicals & drugs formulation in Nigeria, *Continental J. Sustainable Development* 1: 17–22.

[10] Raw Materials Research and Development Council (RMRDC) Multidisciplinary Committee Techno-Economic Survey (MCTS) Report (2003). Chemicals and Pharmaceutical Sector. 4th Update. Pp. 16-69, 102.

[11] Mikota, S. K. and Plum, D. C. (2006). The elephant Formulary. Elephants Care International (www.elephantcare.org/Drugs/Kaolin.htm)

[12] Anderson, J. L. (1997). Pesticide Tolerance Petition Filling. Environmental Protection Agency (EPA) (www://pmep.cce.cornell.edu/profiles/misc_E_N/kaolin/kaolin_pet_0 197.html

[13] https://www.google.com.ng/search?q=map+of+kankara+local+government&tbm=isch&tbo=u&source=univ&sa

[14] Jonah, S. A., Umar, I. M., Oladipo, M. O. A., Balogun, G. I., Adeyemo, D. J. (2006). Standardization of NIRR-1 Irradiation and Counting Facilities for Instrumental Activation Analysis. Journal of Applied radiation and Isotopes, 64; 818-822.

[15] Ahmed, K. S. (1986). Development of Phospate-Bonded Fire Clay Refractory Castables. Unpublish M. Sc. Thesis, Department of Chemical Engineering, Ahmadu Bello University, Zaria.

[16] Robinson Research (1979). Survey of Clay Deposits. In: Ahmed, K. S. (1986). Development of Phospate-Bonded Fire Clay Refractory Castables. Unpublish M. Sc. Thesis, Department of Chemical Engineering, Ahmadu Bello University, Zaria.

[17] Aderibigbe, D. A., Chukwunogo, C. E. B. (1984). Potential of Some Nigerian Clay Deposits as Refractory Materials for the Steel Industry. Paper presented at the Annual Conference of Nigerian Society of Engineers held at Kano, Nigeria.

[18] Kagbu, J. (1988). Comparative Analytical Studies of Some Samples of Locally Produced and Imported Alums Used for Water Treatment. Unpublish M. Sc. Thesis, Department of Chemistry, Ahmadu Bello University, Zaria.

[19] Allen, E. S., Grimshaw, M., Partison, J. A., Christopher, Q. (1974). Chemical Analysis of Ecological Materials. Blackwell Scientific Publication, Oxford, 25 (197), 208-209, 223-224.

[20] Bonny, C. F. (1994). Removal of Iron from Kaolin and Quartz by Dissolution with Organic Acid. Journal of hydrometallurgy, 123, 34-25.

[21] Johnstone, S. J., Johnstone, M. G. (1961). Minerals for the Chemical and Allied Industries. In: Ahmed, K. S. (1986). Development of Phospate-Bonded Fire Clay Refractory Castables. Unpublish M. Sc. Thesis, Department of Chemical Engineering, Ahmadu Bello University, Zaria.

[22] Aggarwal, N. (1983). Application of Geophysical method to delineate kaolin deposits and survey for ground water potentials at Minijibir, Kano State. Unpublished M. Sc. Thesis, Department of Geology, Ahmadu Bello University, Zaria.